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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Measurement Report: Aircraft Observations of Ozone, Nitrogen Oxides, and Volatile Organic Compounds over Hebei Province, China" *by* Sarah E. Benish et al.

Anonymous Referee #2

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This work presents aircraft measurements of O3 and its precursors in Hebei Province, China, aiming at understanding the production of ozone within the planetary boundary layer (PBL). They presented vertical profiles of trace gas species, including O3, NOx, CO, and VOCs. A box model was used to relate those concentrations to the O3 production rate and to assess the O3 production and OH reactivity relevant to the VOC/NOx ratio. Their analysis showed that measured O3 levels ranged from 52 to 142 ppbv, with the peak median concentration (∼94 ppbv) between 1000 and 1500 m. The NOx concentrations exhibited strong spatial and altitudinal variations, ranging from 0.15 to 49 ppbv. They presented the ratios of CO/NOy and CO/CO2 to indicate the prevalence of low efficiency combustion from biomass burning and residential coal burning. Their

measurements of concentrations of total measured VOCs showed that alkanes and alkenes/alkynes were responsible for 74% of the total VOC reactivity, while aromatics contributed the most to the total Ozone Formation Potential (43%) with toluene, m/p-xylene, ethylene, propylene, and i-pentane playing significant roles in the production of O3 in this region. Their box model calculations constrained by measured precursors indicated the peak rate of mean O3 production was ∼7 ppbv/hour below 500 m. They also showed that pollution frequently extended above the PBL into the lower free troposphere, where NO2 mixing ratios (∼400 pptv) led to net O3 production rates up to ∼3 ppbv/hour and this pollution traveled extended distances downwind. They concluded the O3 sensitivity regime as NOx-limited throughout the PBL, while VOC-limited at low altitudes near urban areas. Overall, there are very limited measurements on the vertical profiles of ozone and its precursors as well as an assessment of vertical ozone production and OH reactivity in this region. As such, this work is publishable in ACP, after the following issues have been adequately addressed. Main points (1) I am surprised that they did not found much contribution from biogenic VOCs between May and June 2016 in this region. Ground-based measurements in NCP have clearly showed a role of BVOCs in ozone and PM production (Wang et al., Use of a mobile laboratory to evaluate changes in on-road air pollutants during the Beijing 2008 summer Olympics, Atmos. Chem. Phys. 9, 8247, 2009; Guo et al., Elucidating severe urban haze formation in China, Proc. Natl. Acad. Sci. USA 111, 17373, 2014). Some comparison with ground-based measurements and discussions of the contribution of BVOCs to ozone production would be essential. (2) I would also think that the vertical profile in ozone production within the PBL also reflects photochemistry, which is closely related to PBL height and PM levels. Specifically, it has been known that the PBL height strongly regulates the photolysis rate (O1D) and there exists a strong feedback between PBL and PM (An et al., Severe haze in Northern China: A synergy of anthropogenic emissions and atmospheric processes, Proc. Natl. Acad. Sci. USA 116, 8657, 2019; Wu et al., Aerosol–photolysis interaction reduces particulate matter during wintertime haze events, Proc. Natl. Acad. Sci. USA 117, 9755, 2020). Typically, the trends in sur-

face O3 and PM are believed to be anti-correlated. To what extend the PBL-photolysis interaction would impact their assessments of the vertical ozone production and OH reactivity in the present work? (3) Their measurements were made between May and June 2016. Recent studies have shown significantly different trends in O3 and PM precursors (particularly in NOx) in this region (Zhang et al., An unexpected catalyst dominates formation and radiative forcing of regional haze, Proc. Natl. Acad. Sci. USA 117, 3960, 2020). How did their measurements fit into those of trends for O3 and PM precursors? Minor points In general, the paper was reasonably-well written, but could be further improved to increase its readability. Below are a few examples. (1) The usage between past and presented tenses was interchangeable, but should be made consistent throughout the manuscript. “This analysis shows measured O3 levels ranged from ... The NOx concentrations exhibited ... Ratios of CO/NOy and CO/CO2 indicate . . .” (2) The phrase “26 whole air canisters” in the abstract was confusing. (3) The phrase “we see evidence of” in the abstract was rather causal. (4) The sentence “demonstrating both VOCs and NOx need further control to reduce aloft O3” in the abstract needs to be re-written.

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